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F O R E W O R D

With this the 5th edition, the Quarterly Bulletin enters into the second year of publication. The generous expressions of appreciation which have reached this office from all parts of the world appear to justify our original contention that the Bulletin would meet a genuine need for world-wide information on sulphur.

It is our aim further to enlarge the circle of private subscribers in trade, industry and government departments, and it is hoped that present subscribers will lend us their support.

In view of the widespread interest in the economic utilization of sulphur ores we thought it useful to include in future editions of the Bulletin a review of the principal modern refining processes that have been developed in recent years. The dominating position of Frasch sulphur has, to a large extent, acted as a brake on technical development in this field at a time when separation processes of other minerals were being brought to a high pitch of perfection. Research into economic refining of sulphur ores is beginning to show results and is finding practical application. It is also proposed to include in this series, a review of noteworthy developments in sulphur recovery from industrial gases.

June, 1954.

R E V I E W

Commonwealth countries reviewed in this Bulletin are India and Pakistan. In INDIA sulphur consumption in all forms is at present 145,000 tons. Of this about three-fifths is derived from gypsum used in direct manufacture of ammonium sulphate, and the balance of about 60,000 tons is imported brimstone. The impressive expansion programme of the sulphuric acid industry which, by 1955, is expected to double present acid output to 200,000 t.p.a. is almost exclusively based on brimstone usage. Although, in their

desire for greater self-sufficiency, the Indian Government's Development Council seek to promote the use of the country's abundant pyrites resources, it is thought unlikely that this can be achieved economically for some years to come. The increasing requirements of "regular" sulphur added to anticipated "acid" sulphur usage are expected to raise India's import requirements to about 100,000 t.p.a. by 1955. At the same time, increased ammonium sulphate production from gypsum should raise the country's total sulphur consumption by 1955 to 230,000-240,000 t.p.a.

The sulphur industry of PAKISTAN is as yet insignificant and total sulphur consumption is less than 1,500 t.p.a., almost exclusively in the form of imported brimstone. Abundant resources of sulphur bearing raw materials such as rock sulphur, gypsum, pyrites and the anticipated arising of sulphur recovered from natural gas should promote the steady growth of the country's sulphur industry within the framework of her general industrial development.

The sulphur ore deposits of VENEZUELA, COLOMBIA and ECUADOR are important potential sources of sulphur supply. At the time of the sulphur crisis proposals for large scale extraction and modern refining facilities were put forward, but have not yet materialised. Output in Colombia and Ecuador, still based on autoclave operations, meet little more than domestic requirements of a few thousand tons, while in Venezuela there is no production at all. A modern Chemical Construction Company refining plant installed by Colombia's largest producer, Industrias Purace, is not operating due to the lack of adequate ancillary facilities. In Venezuela and Ecuador development is held up by lack of capital.

In the U.S.A. production of native sulphur in the first quarter of 1954 reached the highest level yet attained in any quarter. Total output of native and recovered sulphur was at an annual rate of 5.85 million tons, or 6½% greater than in 1953. Due to reduced deliveries to the home market and moderate export demand producers' stocks increased substantially, and by the end of March totalled over 3¼ million tons native and recovered sulphur, the highest level since mid-1948.

In the U.K. consumption during the first quarter of 1954 of sulphur in all forms reached the highest level on record, at an annual rate of 860,000 tons, or 14% higher than consumption in 1953. Consumption of brimstone at an annual rate of nearly 375,000 tons continued at the high level of the preceding quarter. Strong industrial activity lifted "regular" sulphur demand to the peak level of 1950. "Acid" sulphur consumption, although still approaching an annual rate of 260,000 tons, represented only 34¾% of sulphur in raw materials for acid manufacture, compared with 38¼% in 1953. By the end of the quarter the addition of new pyrites roasting plants raised consumption to an annual rate of 620,000 tons, the highest on record. Both sulphuric acid production, 3% higher than in the preceding quarter, and consumption, 4% higher, rose to a record level at an annual rate of over 2.1 million tons.

The completion during the summer months of the last new pyrites acid plants installed under the conversion programme is intended to raise further the proportion of acid produced from this raw material to about 40%. With additional 75,000 tons gypsum-acid capacity coming on stream this year, and 225,000 tons in 1955, the pendulum is fast swinging to the other extreme where, as balancing factor, brimstone acid production may account for only about 15% of total output. At a time when brimstone supplies are easy, and there is little to choose in the medium-term supply outlook between brimstone and pyrites, the lack of flexibility of the present position could spell danger to the national economy since an increase in the cost of a basic raw material, such as sulphuric acid, would affect a wide range of industries.

The first in the series of sulphur ore REFINING PROCESSES to be described in the Quarterly Bulletin is the Masobello process, Impianti Speciali per L'Industria, Milan. This is based on retort distillation, and the first plant embodying this process has been in operation for about three months at Montecatini's Perticara mine in northern Italy. The sulphur ore refining process developed by Zahn & Company of Hameln, Western Germany, is based on the use of carbon disulphide as solvent. The first plant using this process has been operating since April by Azufrera Polan, Chile. The full description of the exit

gas plant at the Avonmouth works of the National Smelting Corporation to which reference was made in Bulletin No.4, includes details of the utilization of recovered sulphur in ammonium sulphate production.

The activities during 1953 of the two principal European pyrites producers, SPAIN and CYPRUS, are reviewed. Spanish production at about 2 million tons was nearly ½ million tons (30%) lower than in 1952, due to a severe cut in exports. Exports from Cyprus receded only about 11% partly on account of consumers' quality preference. Cyprus holds the position of the largest exporters within the Commonwealth with nearly 400,000 t.p.a. sulphur content.

There has been no change in world sulphur prices, and none is expected for at least six-nine months. The U.S. domestic sales and export demand is at present being met comfortably. Mexican producers confidently expect to contribute at the rate of about ½ million t.p.a. from autumn 1954 onwards, which, if fulfilled, may introduce a measure of competition into world sulphur markets.

The medium-term supply outlook has been somewhat clarified by the actual confirmation of the existence of an off-shore dome in the Gulf of Mexico. It is, however, doubtful whether at present price levels this could be exploited.

Success in perfecting sulphur ore refining processes that would permit competitive production with Frasch sulphur is thought to be nearer, and this source may, within its quantitatively limited field, help to remove the fear of recurring supply shortage until large scale recovery of sulphur from natural and industrial gases can safeguard increasing long-term needs.

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I N D I A

General

The recent expansion of the industrial economy of the sub-continent of India and particularly the steady growth of the chemical industry focusses increasing attention on the availability and supplies of sulphur. It is significant that, in his presidential address to the 6th Annual Session of the Indian Institute of Chemical Engineers, Dr Kane chose sulphur for his subject. Currently per capita consumption of sulphur in all forms is already about 0.9 lb. which is nearly three times as great as in 1951, though negligible if compared with the United Kingdom where it is about 43 lb., or the United States with 175 lb. There are no known deposits of importance that might provide India's growing requirements of elemental sulphur although the occurrence of pyrites, gypsum and other sulphurous raw materials, together with potential sources of recovered sulphur, make the prospect of comparative self-sufficiency feasible, though not, at present, economically attractive.

Indian industry was severely handicapped by the reduced sulphur import allocation during the crisis of 1951/52, and this experience, together with the desire to expand the use of indigenous sulphur resources has stimulated interest in industry and government departments. Although today about three-fifths of India's sulphur consumption of 145,000 tons per annum is in the form of gypsum used in the manufacture of ammonium sulphate, the sulphuric acid industry is almost exclusively based on the use of imported brimstone, and the needs of the other sulphur using industries are also met by imports. The substitution of indigenous resources in this field is, for the present, unlikely mainly due to disparity in cost between imported sulphur and the domestic substitute, whether it be in its original form, such as pyrites, or refined to produce elemental sulphur. The mere existence of these resources, however, will act as a spur to overcome the present impediments and it is, therefore, thought that their review might be of interest.

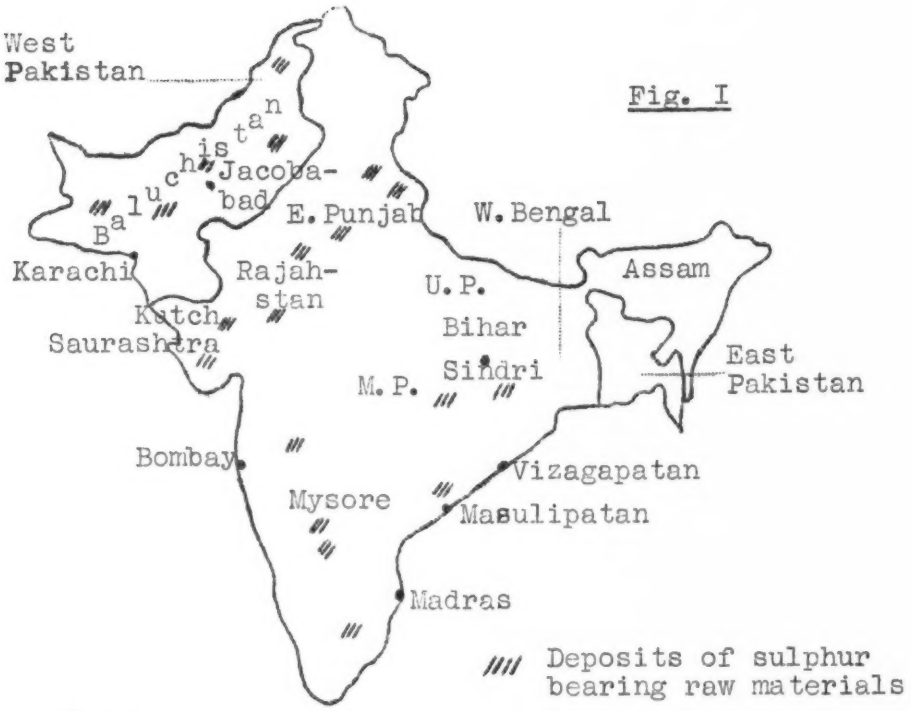


Fig. I

Native sulphur

To date only three elemental sulphur deposits have been discovered. Sulphur bearing clays near Masulipatam, Madras, are being investigated by the Geological Survey of India, in order to determine their extent and quality. Recent tests by the National Metallurgical Laboratory on the flotation of sulphur from these clays containing 21.8% sulphur have resulted in recovery under varying conditions of 80.9% - 94.1%. No detailed information about the other two deposits is at present available, beyond the fact that they are located in the Lodakh and Ruprhu areas. The former deposit is shown to contain sulphur associated with borax.

Pyrites

The occurrence of pyrite deposits is fairly widespread throughout India. In the main, exploratory work has been limited to preliminary stages and, consequently, even in the case of deposits that appear promising little more than an indication of their potential has been obtained.

The following table summarises the position:

Deposit	Measured	Indicated 000s tons	Inferred	Pyrite content of lode	Sulphur	Sulphur content 000s tons
Amjor	-	55	-	86%	44.4%a	24
Taradevi	-	-	1,500	-	30%	60
Ingaladhal	-	500	-	40%	20.81%	104
Devala	200	-	-	90%	48%e	96
TOTAL	200	550	1,500			284

a = average e = estimate

The details shown for the Amjor deposit, which is situated in the Shahabad district of Bihar, are the results of investigation at one of the promising parts of this extensive mineralised zone estimated to contain about 5.7% pyrites. Further investigations have revealed indications of a continuous sheet of pyritic ore estimated to contain over 100,000 tons pyrites, but according to the President of the Geological Mining and Metallurgical Society of India, Mr K. Ray, total reserves of the deposit are in the region of 50 million tons. The possibility of subjecting Amjor pyrites to the Orkla process is also being considered as the deposit is within easy access of cheap coal and coke, and moreover, as it is favourably situated in relation to the industrial regions of Bihar and Bengal, both major sulphur users. The deposits are, however, said to be steeply inclined, thus not permitting easy ore extraction.

The Taradevi deposits occur in thin veins of schistose rock. At some places small scale open-cast extraction is taking place, but extensive working may be rendered difficult if not economically prohibitive on account of the lenticular nature and rapid variations of thickness of the deposit.

The Ingaladhal deposits in Mysore form a well-defined zone covering an area of some 30 square miles, and are associated with a variety of metal sulphides, none of which has yet shown promise of large quantity. The tonnage referred to above was determined on the basis of a geophysical survey and the assay results are based on examinations of one lode.

The Devala deposits contain gold bearing pyrites and the above details refer to proved ore.

In addition to the deposits listed, mention might be made of the important pyrrhotite deposits of Singhbhum, Bihar, which are worked for their copper content, the sulphur fraction remaining, for the present, unused. The investigations into the sizeable nickel-speiss deposits at Kanar, Bombay State, where a million tons ore containing 51%S and 5%Ni are indicated, hold much promise for development in the near future. A monthly production of 4,000 tons sulphur is proposed. According to recent investigations the pyrrhotite deposit of Chitaldrug, Mysore, containing 30% sulphur, is said to show much promise. Current production of pyrites amounts to only a few thousand tons per annum, the latest available production data refer to 1952 when 2,168 tons containing 42%S were produced.

Gypsum

India's estimated reserves of 75 million tons are distributed as follows:-

Rajasthan (Bikaner & Jodhpur)	52 m. tons
Madras (Trichinopoly)	16 " "
Saurashtra, Kutch & Himachal Pradesh	7 " "

At present it is believed that the Bikaner deposit is the only one used as a source of sulphur raw material. Due to the qualitative requirements of the Sindri Fertiliser Plant, the only present user of sulphur in gypsum, only about one-quarter of the total Rajasthan reserves are thought to conform to the minimum required content of 87% $CaSO_4$. Production of gypsum for cement, and, more recently, fertiliser production, has increased rapidly from about 50,000 tons in 1946 to 750,000 tons in 1953, of which nearly 500,000 tons is used by Sindri alone. Further expansion is foreseen.

Smelter gases

The sulphur dioxide in the stack gases at the Ghatsila copper smelter of the Indian Copper Corporation Ltd, are at present going to waste. It is estimated that their utilization would yield about 18,000-20,000 tons

sulphuric acid, or an equivalent of 6,000-7,000 tons per annum sulphur. Similar production of by-product acid could be effected on the Mewar zinc smelter.

Oil refinery gases

The completion of three major projects, two at Bombay and one at Vizagapatam, which are expected to refine over three million tons per annum Middle East crude oil, opens the possibility of substantial sulphur recovery. Depending on the extent of catalytic cracking and desulphurising operations the arising of hydrogen sulphide may permit the recovery of up to 10,000 t.p.a. sulphur. There are no indications so far that the oil installations will comprise sulphur recovery units.

Other potential sources

Investigations include sulphur production by double decomposition of hydrogen sulphide from gypsum and magnesium chloride, which is arising and is being discarded at marine salt works at the rate of $1\frac{1}{2}$ tons for each ton of salt produced; pyrites separation at coal washing plants which, on the basis of current composition of coal could yield about 2 tons pyrites per 100 tons of coal, or an equivalent of about 9,000 t.p.a. These and other sources are being intensively investigated by the Heavy Chemical Section of the Board of Scientific & Industrial Research.

Consumption

During 1953 consumption of sulphur in all forms amounted to about 145,000 tons. Of this tonnage about 90,000 tons was in the form of gypsum used in the direct manufacture of ammonium sulphate, and the balance in the form of elemental sulphur, of which about 40,000 tons was used for manufacture of sulphuric acid, and about 15,000 tons by other industrial users.

The following graph shows details of sulphur consumption for the period 1949-53, and an estimate for the period 1954-56.

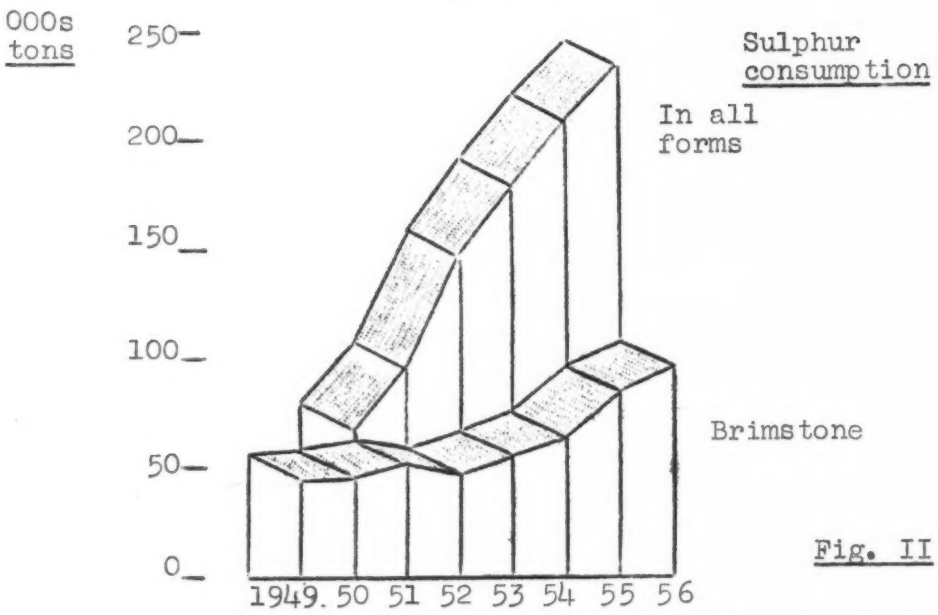


Fig. II

The recession of elemental sulphur usage in 1952, shown above, was primarily due to reduced activity in the sulphuric acid industry, as, at that time, extensive plant replacements were being effected. The increasing rate of sulphur consumption from 1954 onwards is expected to be brought about by the large number of new acid plants progressively coming on stream and by the additional requirements of other sulphur using industries, notably rayon and dyes.

Imports

With the exception of some 7,500 tons sulphur imported in 1952 from Japan, India draws its imported sulphur exclusively from the U.S. It is reported that, during the past six months, Japanese suppliers have tried to re-enter the Indian market with competitive offers. Indian sulphur users are, however, believed to have anxieties regarding quality, mainly on account of the selenium content, and they may, for this reason, be looking for a greater discount compared with the landed price of U.S. supplies. Imports were as follows:-

1949	39426	tons	1952	65776	tons
1950	56488	"	1953	51883	"
1951	38507	"			

Sulphuric acid

The sulphuric acid industry is wholly controlled by private enterprise. It was the first branch of the chemical industry to be established in India, about the end of the 19th century, when the first plants were being operated by D. Waldie & Company, the Bengal Chemical and Pharmaceutical Works in Bengal, Parry & Company in Madras, and Eastern Chemical Company in Bombay. Throughout the first World War and immediately after it, many new plants came into existence, including India's first contact acid plant built by the Tata Iron & Steel Company to meet their acid requirements for iron pickling and for utilising by-product ammonia in ammonium sulphate production.

During the 1930's, due particularly to foreign competition in acid based salts, more than half the installed acid making capacity was idle. During this period the use of pyrites gave way to imported brimstone. Under the stimulus of industrial activity during the second World War installed capacity was again fully employed.

From about 1946 onwards, when installed acid capacity was 60,000 t.p.a., a series of new installations were erected so that by 1950 some 43 units -30 chamber, 13 contact plants, with combined capacity of 150,000 tons were operating. Coincident with severe limitation in acid production at the time of the sulphur crisis, which restricted plant employment to about 65% of capacity, significant progress towards modernization was made by the industry by scrapping a number of old chamber plants and the introduction of eight new contact units. By June, 1952, the regional distribution was as follows:-

State	No. of units		Annual rated capacity (100% H_2SO_4) tons		
	Total	Contact	Chamber	Contact	Total
Assam	1	1	-	6,600	6,600
West Bengal and Bihar	13	7	12,660	43,900	56,560
Bombay	12	7	11,913	23,100	35,013
East Punjab and Delhi	9	2	8,355	6,600	14,955

State	No. of units Total	Contact	Annual rated capacity (100% H_2SO_4) tons Chamber	Contact	Total
Uttar Pradesh	4	-	5,775	-	5,775
Madhya Pradesh	1	-	825	-	825
Madras	2	1	5,280	8,250	13,530
Former Indian States and States Unions	5	3	3,713	52,470	56,183
TOTAL	47	21	48,521	140,920	189,441

Since then further development has taken place on similar lines, and it is believed that, at present, only 37 units are in operation; at the same time, a large number of plant expansions and some new constructions have been completed. Amongst new developments in hand, the following are of particular interest:-

Tata Iron & Steel Company are replacing their existing plant (capacity 15,200 t.p.a. acid) by a new contact plant with a capacity of 25,000 t.p.a.

Bengal Chemical & Pharmaceutical Company are increasing the capacity of one plant by 150% to 25 tons per day, and doubling the capacity of their second plant to 4,500 t.p.a.

East India Distillers & Sugar Factories are increasing capacity of existing plant of 19,850 t.p.a. by the addition of a contact unit of 3,000 t.p.a.

India Chemical Industries are trebling the capacity of their plant to 4,500 t.p.a.

New contact acid plants with an annual capacity of about 8,250 tons are reported to be under construction by the Bihar Government Superphosphate Factory, Sindri, Gwalior Rayon Manufacturing Company, Nagda, and Phosphate Company Limited, Calcutta. Of these the last named is believed to be completed, whereas the others are due to come on stream later this year.

Two developments, the only ones at present envisaging the use of raw materials other than sulphur, should be mentioned.

The Rajah of Venkatagiri has projected a super-phosphate plant based on acid manufacture from gypsum. The capacity of the plant, which is being built by Zahn & Company of Hameln, Germany, is to be 6,600 t.p.a. acid, a surprisingly small unit for this type of operation, and it is expected to be completed in 1955. The other new development is to be based on the use of pyrites. It is understood that the Development Council, which controls and licenses the erection of new plants, may designate a manufacturer to undertake this, and it has been mooted that, as this development is somewhat experimental, a specific subsidy may have to be made to indemnify the company undertaking it.

The significant aspect of all the above developments is the gradual trend away from the small acid units that used to be the rule with attendant high production costs. Whereas in the past, due to a comparatively low level of industrial activity and its wide distribution, the small unit development and, in case of increased local requirements, the duplication of such small units, was virtually inevitable, the present plans tend to favour units of at least 25 tons per day, but preferably 50 tons per day acid, sited in relation to consuming industries. In the case of future plants based on indigenous pyrites or gypsum it is envisaged that these should have capacities of 50-100 tons per day acid, and should preferably be located near their source of raw material. At present the largest single plant is that of FACT Limited with a daily rated capacity of 75 tons.

By 1955/56 it is anticipated that total acid capacity will be of the order of 220,000 t.p.a. at 51 plants, with actual acid output of 200,000 t.p.a.

Consumption of sulphuric acid is distributed approximately as follows:-

Industry	%age consumed	Industry	%age consumed
Sulphate of ammonia	8.3	Textiles	14.3
Superphosphate	21.5	Other acids	12.2
Steel metal	12.2	Other chemicals	17.5
Automobiles	1.8	Special uses	12.2

The most important increase may be expected in superphosphate manufacture which in 1953 amounted to about 48,000 tons. During 1954 this is to be raised to 120,000 tons, by 1955 to 160,000 tons, by 1958 to 230,000 tons.

Other important consumer developments are anticipated in the textile industry as a result of new rayon production having been started, in the iron and steel industry, where large scale government sponsored development is taking place with a view to raising coke oven and steel making capacity, and in the oil industry where the acid requirements of the three new refineries will be significant.

Regular sulphur

Currently requirements of industries other than sulphuric acid are about 13,000-15,000 t.p.a. Of this tonnage about 7,000 t.p.a. is sulphur used by the sugar refining industry for purification of sugar juice, and the balance is believed to be distributed as follows:-

Rayon (CS_2)	51%	Soda ash	7½%
Paper	24%	Agriculture	7½%
Fine chemicals	10%		

It is anticipated that regular sulphur consumption by 1955/56 may rise to about 20,000 t.p.a., the major increase being taken up by rayon and fine chemicals (incl. dyes).

Gypsum

Consumption of gypsum for direct sulphate of ammonia manufacture at Sindri during 1953 amounted to 445,011 tons. Although substantial expansion of

fertiliser capacity is envisaged at Sindri this relates mainly to nitrogenous fertilisers other than ammonium sulphate, such as urea and ammonium sulphate nitrate. Further expansion of gypsum consumption to about 700,000 t.p.a., 150,000 tons sulphur content, is envisaged over the next 3-5 years. In addition to the gypsum acid plant project mentioned above, investigation intc the suitability of Trichonopoly (Madras) gypsum is reported by FACT Ltd who contemplate the construction of an ammonium sulphate plant. Ammonium sulphate requirements in 1954 are expected to rise by 100,000 tons to 420,000 t.p.a., and by 1958 they are expected to amount to 800,000 t.p.a.

Price

During 1953 the price trend in India of imported sulphur has reflected the increase in the U.S. export price. Thus, in the early half of the year, American sulphur was landed in India at about £14.10s and later in the year at about £16.5s. The recent offers of Japanese sulphur were made at £16 c.i.f. per metric ton. Refined sulphur imports are believed to have fluctuated considerably within a price range of £22.10s to £25 per ton.

Conclusion

The significant developments of India's industrial economy are, as would be expected, reflected in her sulphur using industries. The likelihood of an early reduction of her dependence on sulphur imports is remote as the large scale developments, notably of Indian pyrites resources, would not only demand very large capital expenditure but their employment in preference to sulphur would result in a substantial increase in acid prices. This would undoubtedly have serious repercussions on many vital industries, some of which, being newly established, may not be in a position to absorb a sudden increase in the cost of a basic raw material. On the contrary, for at least the next three years India's sulphur import needs can be expected to increase, and by 1956 are likely to be in the region of 100,000 t.p.a. At the same time, it is reasonable to expect that such by-product acid and recovered sulphur projects as are economically viable

will be executed and will contribute their share of the country's sulphur needs. In view of the increasing use of gypsum in fertiliser manufacture, the country's sulphur balance would thus not seem unfavourable, and Indian industry may then, in the light of trends of world sulphur availability, be in a better position to determine its need to establish an even greater measure of self-sufficiency.

P A K I S T A N

General

The sulphur industry of Pakistan is, as yet, at a very low level of development. This applies primarily to the consumer side of the industry, although as detailed below, relatively important plant additions are in the course of construction. Pakistan possesses fairly extensive sources of sulphurous raw materials in the form of rock sulphur, gypsum, pyrites and the imminent arising of sulphur recovered from oil refinery gases, and their existence will constitute an important factor in the future of the industry. To date, the plans of the Pakistan Industrial Development Corporation do not provide for specific development of the country's sulphur resources, nor is there a fixed programme in respect of sulphur using industries. For the time being the country's sulphur requirements and supply are dealt with on an ad hoc basis.

Resources

Native sulphur:

(a) The most important deposit is that of Koh-i-Sultan in Baluchistan. It is of volcanic origin and sulphur occurs impregnated in clay and associated with gypsum. At present there are some 85,000 tons of proved ore situated in three areas, i.e.,

Batal	15,000	tons	low grade	(25%-40%S)
Miri	(40,000	"	high "	(50%S plus)
	(17,000	"	low "	(25%-50%S)
Nawar	(7,000	"	high "	
	(6,000	"	low "	

It is believed that detailed exploration is likely to determine much larger tonnages. During the war, from 1942-45, large scale extraction yielded on treatment some 60,000 tons sulphur of about 96% purity.

(b) At Sunni, in Kalat State, Baluchistan, large deposits of low grade (30%S) ore, associated with bitumen, have been determined. Very little exploratory work has yet been carried out due to extreme heat for all but two-three months of the year, and the difficulty of access, the deposit being some 50 miles from the nearest rail head in country devoid of roads.

(c) Near Jacobabad Sind preliminary investigations are said to have proved 50,000 tons ore containing 60%S, associated with small quantities of gypsum. The deposit is described as being some 20 feet thick.

(d) Deposits of sulphur rock are also reported in Chitral.

Earlier this year the Industrial Research Laboratories at Karachi, which are sponsored by the Pakistan Ministry of Industries were reported to have developed a new sulphur refining process specially applicable to Baluchistan ores. No details are as yet available.

Gypsum and Pyrites: (B)

In the following table the principal deposits are shown.

Deposit	S. content	Availability
Gypsum		
Daud Khel (Daudkhel)	18.7%	37 m. tons.
Khewra	18.7%	Large deposit. Extent not determined.
Spintangi	18.7%	Large deposit. Extent not determined.
Baluchistan/ Kalabagh area	18.7%	Many gypsum deposits 10 ft. or more thick. Extent not determined.

INSERT (C)

(over)

Deposit	S. content	Availability
Pyrite		
Shingarh Gilgit	-	Associated with extensive coal deposits.
Shingarh	-	In saddle reefs; no sizeable concentration.
Gilgit	-	Large veins 40% pyrite. Quantities not determined.

Sulphur in natural gas - Sui Gas field+

The Sui Gas field is located in the dry desert region of N.E. Baluchistan, 50 miles north-east of Jacobabad in Western Pakistan. The area has low hills and geologically it consists of sedimentary rocks folded into a large dome, the gas being contained in the pore spaces of a thick eocene limestone at a depth of about 4,000 feet.

The field was discovered by Pakistan Petroleum Ltd, a subsidiary of The Burmah Oil Company Ltd, who had drilled an exploratory well down to below 10,000 feet. No oil was found, but tests carried out in October, 1952, gave a strong flow of gas. The second test well confirmed the presence of an extensive natural gas field, and development is now proceeding with the drilling of a number of further wells.

Early this year the Sui Gas Transmission Company was formed to construct, own and operate the transmission system which will consist of a 350 mile 16" diameter high pressure pipeline from Sui to Karachi via Sukkur and Hyderabad, with connecting lines to large consumers. Approximately three-quarters of the shares in Sui Gas Transmission Company will be held by The Pakistan Industrial Development Corporation, The Commonwealth Development Finance Company, and The Burmah Oil Company Ltd, the balance being held by private investors in Pakistan. A loan of £5 million to Sui Gas Transmission Company for the construction of the pipeline has been sanctioned by the International Bank for Reconstruction and Development.

First shipments of the pipeline from Stewarts and Lloyds rolling mills have already been made. Before being laid in a trench, the pipe will be wrapped for protection

+ We are grateful to the Burmah Oil Company for the above details.

from external corrosion and cathodic protection will also be used. It is expected that the pipeline will be completed by the middle of 1955.

The gas consists of methane with a very small proportion of higher hydrocarbons, 7%-8% carbon dioxide, and about 120 grains of total sulphur per 100 cubic feet of gas, of which the major part is hydrogen sulphide; there are also some mercaptans.

Before the gas is passed to the main pipeline from the wells it will be necessary to remove the major part of the corrosive sulphur compounds, carbon dioxide, and water vapour and this will be done in Sui. Design of the gas collection system from the wells and of the purification plant is still under discussion, but plans will be completed in the near future. The purification process will consist essentially of an amine unit for hydrogen sulphide absorption which will also remove the carbon dioxide, followed by a caustic soda unit for removal of mercaptans, and this, in turn, will be followed by a dehydration unit. Initially, the hydrogen sulphide and carbon dioxide will be vented to the atmosphere whilst the mercaptans will be burnt.

Bulk gas sales to factories and plant in Karachi and at important centres en route will rise from 37 million cubic feet per day to over 110 million cubic feet per day in a few years. The proved reserves of Sui gas have been estimated as more than 2¼ million cubic feet. At the above rate of gas consumption it is estimated that about 2,500-2,700 t.p.a. sulphur could be recovered.

Consumption

Brimstone:

At present consumption of sulphur is about 1,350 t.p.a. Of this about 700 tons is used in sulphuric acid manufacture, 500 tons in sugar refining, 150 tons by miscellaneous industries, notably match and rubber. Requirements are wholly met by imports which are as follows:-

1949	208 tons	1951	625 tons
1950	1,095 "	1952	2,100 "

Sulphuric acid:

The following table gives details of sulphuric acid production for the period 1948-53:

1948	110 tons	1951	800 tons
1949	100 "	1952	1,000 "
1950	370 "	1953	1,400 "

The following plants are available:

In West Pakistan, one 10 tons per day contact plant and one 300 tons per annum old chamber plant. The installation of a 20 tons per day contact plant at Lyallpur, West Punjab, is almost completed. In East Pakistan, the only existing plant is the old chamber installation of 300 t.p.a. capacity, but this is not working. A modern 10 tons per day contact plant is being installed at Chandragona, East Bengal.

Sulphur in gypsum:

Pakistan's first major fertilizer plant is at present under construction at Daud Khel in Multan district, adjacent to the gypsum deposit similarly named. For this £4½ million project initial finance to the extent of £1½ million was provided by the U.S. Technical Cooperation Administration (T.C.A.). When completed in 1956, it is to be operated by the Pakistan Industrial Development Corporation, and will have an output of 50,000 t.p.a. Of this, a large proportion is to be ammonium sulphate produced directly from gypsum. Consumption of gypsum is expected to reach about 200,000 t.p.a. (containing 37,000 tons sulphur).

Conclusion

There is little doubt that the modest developments of the sulphur using industries are merely forerunners of substantial activity in connexion with the fertiliser and metal industries. The natural gas project should play a very important part in the speeding up of general industrial development by providing a valuable source of energy, and also of raw materials for the chemical industry. The

availability of sulphur from this source and the comparative abundance of other sulphurous raw materials will inevitably act as a stimulus for the rapid growth of the country's sulphur industry.

VENEZUELA, COLOMBIA & ECUADOR

General

The three northernmost countries of the South American continent attracted much attention when, at the height of the sulphur crisis, more or less extravagant claims were advanced by newly constituted companies who proposed to place immediate ample supplies at the disposal of sulphur-hungry world markets. A few thousand tons were indeed forthcoming at much inflated "free market" prices of £120 per ton or more, but the large scale productions at prices competitive with U.S. sulphur did not materialise.

This was not due to any lack of sulphur deposits, even though the extent of some, based on superficial estimates, were exaggerated, but rather due to lack of capital for the installation of the modern refining plant required for such production. In many cases promoters took for granted the availability of an economical ore refining process, although experience of such operations was lacking.

All three countries have moderate sulphur requirements for their own established consuming industries. With the exception of Venezuela, where production is still virtually non-existent, the present extent of their sulphur output meets current internal requirements of up to 4,000 t.p.a. This demand is steadily growing as new projects in fertiliser, rayon and fine and heavy chemical industries move from the planning to the construction stage, and there is little doubt that sulphur production will at least keep pace with these developments.

In the case of Colombia and Ecuador, the northern end of the Cordillera Central forms the backbone of the

country. Like the more southerly part in Chile, the volcanic origin of the mountain range is manifested by sulphur deposits in extinct craters, near the orifices of fumaroles, and in sediments around hot sulphur springs occurring at considerable altitudes of up to 16,000 feet, though not infrequently below 12,000 feet. The Venezuelan deposits are also of volcanic nature, but occurring along the fault zone in low-lying hilly country they differ considerably from their Andean counterparts.

Venezuela

Resources:

The existence of sulphur at El Pilar ~~in the State of Sucre~~, 15 miles south of the port of Carupano, has been known for over 100 years and actual exploitation at the end of the nineteenth century was carried out by a German firm, who mined rich sulphur outcrops, and transported the ore by overhead cable railway to Carupano for export shipment to Germany. Due to political unrest at that time exploitation ceased just before the outbreak of the first World War.

The deposit consists of sulphur impregnated calcareous rock with a sulphur content varying between 25%-70%, and estimated average of 50%. The main concentration of deposits which occur at or near the surface is in an area of about 2,000 acres, situated at about 1,000 feet above sea level, in a hilly jungle-covered region. There are customary manifestations, such as solfatara, gas eruptions, hot springs, etc. As no comprehensive survey has ~~yet~~ been effected, estimates of reserves vary between ½-1 million tons sulphur contained, but it is probable that a substantially larger tonnage may be developed. According to unconfirmed reports, the existence of a sulphur dome has been inferred in the course of recent exploratory work. No evidence to this effect is, however, available, on the contrary, all data throw considerable doubt on such a possibility.

In 1952 the Venezuelan Sulphur Corporation, which was formed by U.S. interests, acquired the title to the El Pilar property, and was granted a 50-year concession by the Venezuelan Government, as well as options in respect

of adjacent mining areas. Originally the company intended to carry out large scale exploitation with a view to producing by partial beneficiation about one quarter million tons of 95% sulphur material. This project was abandoned, and it is understood that, at present, construction of a refining plant is contemplated to yield 50,000-100,000 tons of 99.5% sulphur. So far Venezuelan Sulphur Corporation has carried out some exploratory work and a limited amount of development, but to realise their project outside capital would have to be forthcoming. During the past 18 months, American, French and U.K. interests have considered the project, but so far no such participation has taken place.

The second sulphur deposit of importance was discovered ~~last year~~ in 1953 at Puerto Puritu ~~in the State of~~ Anzoategui. The preliminary survey of the deposit known as Fray Matias, ~~by Dr Garriga and Professor Vila of the University of Venezuela,~~ indicated the existence of about one million tons of sulphur ore containing about 25% sulphur. A concession which covers an area of about 1,100 acres is owned by Sr. Carlos Acedo Mendoza. At present, neither exploration nor exploitation is being carried out, and none may be expected unless foreign capital takes an interest in the project.

Consumption:

The entire sulphur requirements of Venezuela are met by imports, and these are augmented by imports of sulphuric acid. During 1952/53 they were as follows:-

	1952	1953
	tons	
Sulphur	309	1,258
Sulphuric acid	1,426	607

In 1953 Venezuela's only sulphuric acid plant was constructed by Manufactures de Algodon INCA. It has a capacity of 15 tons per day, and serves to meet primarily the requirements of the new rayon plant, but also local soap and dye industries at Maracay.

Following the discovery of a major phosphate rock deposit of good quality 30 miles south-east of Jacuro,

plans are now under consideration for the production of phosphatic fertilisers at the rate of 9,000 t.p.a. A similar development in the field of nitrogenous fertilisers is planned by Corp. Venezolana de Formento, who propose to utilise natural gas supplies in ammonium sulphate manufacture at the rate of 36,000 t.p.a. If realised, substantially greater acid supplies would have to be made available.

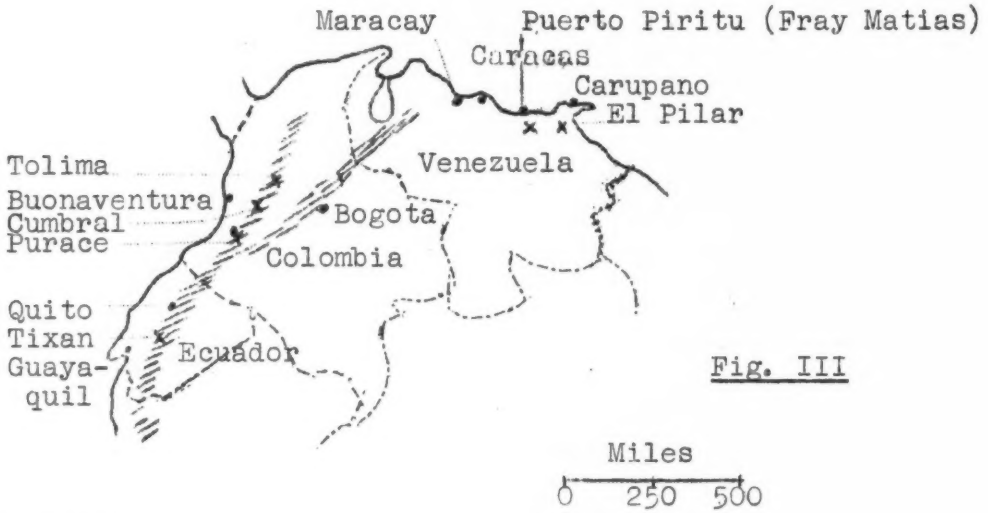


Fig. III

Colombia

Resources and production:

The number of sulphur deposits in the Colombian section of the Cordillera Central is very considerable. Most of the deposits are small, having been formed by fumaroles and springs near the craters of extinct volcanoes.

Of these, the Cumbral deposit is thought to be of economic interest, and during the early 1940's Indians Of Narino were exploiting it in a small way for the domestic sulphur market. At this deposit sulphur occurs in a secondary volcanic crater some 50 metres deep and 100 metres across, located just below the snow level at an altitude of about 16,000 feet.

Promising deposits are also found at Lake Otun and La Selva along the crest of the Cordillera, near the peaks of Ruiz, Santa Isabel, Quindio and Tolima, which may be reached by trail from the railhead at Caldas, or nearest road at Tolima.

At Otun there are over 100 active or extinct fumaroles within an area of about one acre situated in a steep slope at the southeast outlet of the lake. Sulphur was deposited in crystals in the orifices of the fumaroles, and as impregnation in tuff surrounding them. Nearly all the sulphur crystals have been mined long ago.

At La Selva springs have deposited very fine grade sulphur within the volcanic detritus. These are present in the form of lenses in the vicinity of the springs.

Sulphur is also found at Azufrado in separate masses ranging up to several acres in surface of volcanic debris cemented by sulphur.

The most important deposit was discovered in 1940 by Dr Mosquera in the crater of the extinct Purace volcano, where exploration has proved some 6 million tons of sulphur. This deposit is being exploited by Industria Purace S.A., which was formed by Dr Mosquera and in which important rayon and textile interests as well as Messrs W.E. Grace & Company of New York hold interest. The original refining plant consisting of three autoclaves is situated adjacent to the mine at El Vinagre at an altitude of 11,200 feet, some 10 miles above the village of Purace and 30 miles by road Popayan, whence the rail distance to the port of Buonaventura is about 230 miles.

The company holds a concession area of about six square miles for a period of 30 years, after which, together with all plant and machinery, it reverts to the Government. The ore contains 40%-50% sulphur, but pockets of ore with higher sulphur content are not unusual. Extraction is by underground methods, but in view of the satisfactory consistency of the ground the mine tunnels require no support and lorries can drive right into the mine workings. With a view to increasing production, and to obtaining this at economic costs, the company decided to instal a modern sulphur refining plant.

and instructed the Chemical Construction Company to install a 12,000 t.p.a. plant. As reported in Bulletin No.3, this plant is not operating owing to "technical difficulties". According to reliable sources these consist mainly of the inadequacy of ancillary equipment, such as boilers, and difficulties in ensuring regular flow of ore to the new plant. It is understood that at present the company only operates by autoclave refining.

During 1953 sulphur production in Colombia amounted to about 4,000 tons, almost exclusively origination from Industria Purace S.A. In view of the cost inherent in autoclave operation, sulphur is available at $80-$100 per ton f.o.b. Buonaventura. It is reported that Industrias Purace propose to increase production by the addition of three further autoclaves, one being constructed locally and two at present on order from Germany. Their addition is expected to double current production.

Consumption:

The entire output of Industrias Purace, as well as any small tonnages mined by Indians at fumarole deposits is consumed locally as follows:-

By rayon industry	2,400	tons
By sulphuric acid industry	600-1,200	"
Miscellaneous	600	"

With the exception of some fine ground sulphur for special uses, there are no sulphur imports, the home producer being protected by high import duties. The above mentioned increase in production is the result of a rising trend in local sulphur requirements.

Ecuador

Resources and production:

Situated astride the Cordillera Central, Ecuador, like Colombia, has many deposits of sulphur. The majority are commercially insignificant, and until 1951 exploitation was limited to sporadic removal of crystalline sulphur from fumaroles, mostly carried out by Indians. The most significant deposit is that at Tixan about 10 miles

northeast of Alausi, near the Quito-Guayaquail railway. This deposit has been worked on a very small scale for a number of years, the mineral rights belonging to the Public Assistance Board of Chimborazo, to whom it had been assigned by the Ecuadorian Government.

In 1951, following some exploratory work, the Chemical Plants Corporation of New York, a subsidiary of the Von Kohorn group, obtained a 20-year concession from the Government giving it full exploitation rights. The conditions of this contract were rather onerous in that, in addition to a rental of 10% of the production for the first 10 years and 12% thereafter, payable in cash or produce, a minimum of a quarter million sucres, or 20% of the net profit of the mining operations, had to be paid to the Public Assistance Board. The company also had to undertake to construct a sulphuric acid plant with a capacity of five tons per day, supplying acid to the national economy at not more than cost plus 20%. Chemical Plants Corporation formed an operating subsidiary, the Ecuadorian Sulphur Company, which engaged in the actual exploitation of the sulphur deposit.

Only limited exploration was carried out and various reports estimated reserves at between 0.1 and 1 million tons sulphur contained. The ore has a much lower average content than that usually found in Andean deposits, being 22%-23% sulphur. Initially the company installed a number of autoclaves, intending to replace these by a modern refining plant, after having attracted foreign capital to assist them in this venture. This development did not, however, materialise, and small scale autoclave production has been carried on since then. The Ecuadorian Sulphur Company also holds concession rights in respect of a second deposit nearby, which is reported to be similar in size and quality to the Tixan deposit.

Ecuador also possesses sulphur resources situated on the Galapagos Islands. Those on Isla Isabella (Albemarle Island) have been investigated in some detail, and two deposits have been identified near extinct volcanic craters at an altitude of 4,000-5,000 feet. It is estimated that they contain about 100,000 tons sulphur ore with an average content of 50%, though some of the sulphur present is reported to be 99% pure. Sulphur deposits are

known to exist on James Island (San Salvador), Chatham Island (San Cristobal), but neither have yet been investigated in detail. On all islands, in addition to the sulphur deposits resulting from fumarole activity (bocanas) and the action of hydrogen sulphide and thermal springs on limestone, there are also deposits where sulphur is associated with gypsum, limestone calcite and other minerals. The latter occur in lenticulur deposits.

Production:

Up to 1951 annual production was under 100 tons refined sulphur. Since the operation of autoclaves by the Ecuadorian Sulphur Company production intermittently reached over 4,000 t.p.a. From March-April, 1953, production had ceased altogether, but at present it is again believed to be carried on at a normal rate to meet local requirements.

Consumption:

Current consumption of sulphur is estimated at about 3,000 t.p.a. Of this tonnage about 2,700 tons is consumed by the sugar mills, about 200 tons by hat manufacturers, and the balance by miscellaneous uses.

It is not known whether the Ecuadorian Sulphur Company implemented its obligation to construct a small sulphuric acid plant.

Exports:

In 1952 the Ecuadorian Sulphur Company exported 2,700 tons refined sulphur, of which 2,500 tons were shipped to Brazil and 200 tons to India. No details are available for 1953, but exports are believed to have been small due to much reduced production.

Conclusion

The development of the three countries' sulphur resources, though not as urgent as in 1951/52, is today at least as desirable. Whereas the comparatively small increases in production required to meet internal demand

will undoubtedly materialise, these are not thought to represent real progress, as they usually take place under price conditions that do not conform to world market levels. Perhaps Industrias Purace in Colombia are nearest to attaining the desirable status of competitive exporters since a comparatively small additional capital outlay is likely to enable them to achieve economic output from their modern refining plant. Elsewhere, the searching conditions to be met if substantial foreign capital is to be attracted await fulfilment. Perhaps the present climate of ample cheap Frasch sulphur supplies does not favour comparatively unknown new ventures, but the rich deposits of these countries, as those of Chile, may in the not too distant future be required to meet an increasing world demand that today's established sources will no longer be able to supply.

PRICES AND TRENDS

Prices

During the past three months practically no changes have taken place in the world price structure. The U.S. export prices maintained their level of $31 (Texas Gulf Sulphur, Freeport Sulphur, Duval Sulphur & Potash Companies) and $33 (Jefferson Lake Sulphur and Standard Sulphur Companies) per ton bright sulphur f.o.b. Gulf ports. These prices appear to form the basis of tentative negotiations starting in respect of Mexican Frasch sulphur which is expected to reach export markets later this year.

The price level of Italian export sulphur remains at about L.42,000-45,000 (£24-£26), and no change may be expected while the entire question of rational production and export policy is under consideration at high governmental level.

From Japan occasional offers of individual parcels are made in specific markets, such as India, competitively with the landed price of American sulphur. No acceptances have, however, been reported recently.

The Chilean Government are reported to have expressed their willingness to authorise sulphur exports at price levels similar to those of American sulphur, permitting producers to dispose of foreign currency earnings on the local free market, and also to give favourable consideration to commodity compensation deals. No such transactions have, however, taken place recently.

In view of the favourable supply position no advances in the U.S. sulphur price level may be expected for at least 6-9 months, when the realization or otherwise of the expectations of Mexican supplies should exert appropriate influence.

The following table shows a comparison of prices of sulphur of different origin. F.o.b. prices and freights are based on recent quotations.

	f.o.b. Country of origin	Freight to U.K.	c.i.f. U.K.
United States	$31 ($33)	48/- $16.50*	£13½ & £17 Av. say £14
Mexican Gulf	$31-$33	52/6	£14
Italy/Sicily	£24-£26	35/-	£25¾ - £27¾
Chile	£11¼	67/6	£14⅝ - £15
Japan	$38+	72/-	£14⅝ - £15
Iraq	-	-	£14
Ecuador	$40	64/-	£17½

* 50% of U.S. sulphur exports have to be moved in U.S. bottoms; whereas U.S. liner freights are at present equivalent to about 50/-, U.S. tramps usually command premium freights.

+ Calculated on the basis of their sales to Australia in 1953.

The level of European pyrites prices is at present undergoing examination. During the past 2-3 years the official and supra-national emphasis on the need to switch from sulphur to pyrites had, to some extent, diverted the consumers' attention from the fact that since 1950 the all-values price of pyrites had nearly doubled to about £7 - £7.10s per ton landed in U.K. and Western Europe, whilst during the same period the price of U.S. sulphur had increased only about 40%. The disparity has perhaps been further aggravated recently by the unfavourable turn in the residues position. Their value has depreciated by at least one-third due to lower iron ore and non-ferrous metal prices, compared with 1952/53 peak levels. Furthermore, in recent months a severe reduction in the intake of Germany's cinders extraction plants, due to their holding nearly one year's stocks, appears to have reduced further the potential proceeds that acid makers seek in order to keep down the prime cost of sulphur in pyrites.

It is estimated that, whereas in 1950 on the basis of ruling prices of raw materials and acid plant and operating costs in the U.K., the use of sulphur as against sulphur in pyrites showed an advantage of about £.10½ per unit of sulphur consumed for acid making in a contact plant of, say, 60,000 t.p.a. capacity, the difference today is nearly £.16.

The price of Spanish pyrites is by and large the yardstick of the industry, and in this respect at the recent annual meeting of the Rio Tinto Company the Chairman, the Earl of Bessborough, drew attention to a further increase in cost of labour and social services in Spain which intimately affect production costs. Thus, however desirable a reduction of pyrites prices may be it is not thought likely that this may take place.

Supply

The supply position of cheap American Frasch sulphur is at present easy. The reduced domestic demand during the first quarter of the year, due to lower consumption and reduction of consumers' stocks, and moderate exports coinciding with the high level of production, as a result of successful operations at the new domes of Freeport

Sulphur Company, led to a substantial increase in American producers' stockpile.

From Mexico, the two companies operating the San Cristobal and Jaltipan domes confidently expect to start exporting during the autumn of 1954. As far as is known, neither have yet entered into commitments, but both are vigorously examining world markets and demand. The President, Mr H.C. Webb and the Vice-President, Mr L. Townsend, of the Pan American Sulphur Company sought personal contacts and impressions during a visit to principal markets in April and May of this year.

As a result of the export contracts concluded early this year, Chilean producers were more active in recent months. A setback is, however, reported following the cancellation of the major proportion of their U.K. contract on account of qualitative shortcomings in the supplies from one of the major producers, the limits of permissible arsenic content having been exceeded.

In Japan, the picture is unchanged with production being aligned to domestic demand at a level similar to that of 1953 (see p.58). Italian production has receded slightly in recent months. Nevertheless in the virtual absence of exports and contracted home consumption, the stockpile continues to grow, and is believed to exceed a quarter million tons. Scandinavian and German sulphur productions and the arisings of recovered sulphur in Western European countries continued to be absorbed by the domestic industries of the countries concerned.

Whereas U.S. domestic consumers, confident in their ability to obtain quick sulphur supplies should they be needed, have reduced working stocks, it is not thought that importers of U.S. sulphur are justified in following a similar policy although this view has been expressed in some quarters. There are already signs that consumers in Western Europe have also reached this conclusion and are backing their increased sulphur consumption by increased working stocks. It is felt that within the limitations imposed by the sales policy of U.S. producers sulphur consumers throughout the world, particularly in countries where the industry is largely dependent on imported sulphur, should avail themselves of the present easy supply position which, after all, may not be of long duration.

UNITED STATES SULPHUR

Native sulphur

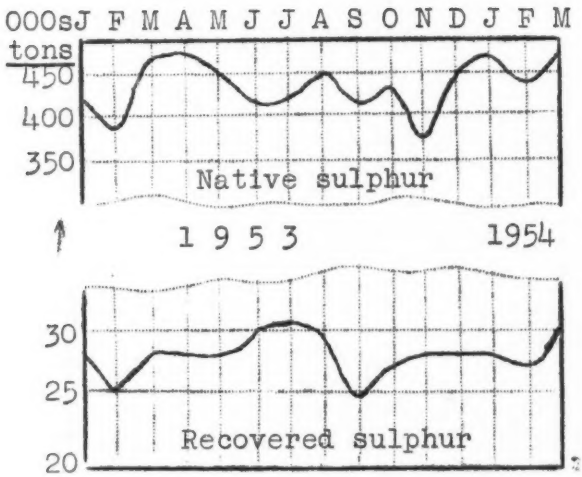
During the first three months of 1954 production rose to the highest level yet attained in any one quarter. At 1,378,248 tons native sulphur, production exceeded the previous best in the second quarter of 1952 by about 20,000 tons (1½%), and was over 100,000 (8½%) higher than during the corresponding period of 1953. This surge in output is largely attributable to successful operations at Freeport's Garden Island Bay Dome, which, since January, has yielded over 40,000 tons per month.

Apparent sales during the first quarter of the year were comparatively low at 1,161,896 tons. They were about 113,000 tons (8¾%) below those of the preceding quarter, and 135,000 tons (10½%) less than during the corresponding period of 1953. Of the above tonnage, exports amounted to 304,344 tons, which is 4½% below the export rate during the preceding quarter, but 25% higher than export during the first quarter of 1953. Thus the reduction of sales is almost exclusively due to lower deliveries to the home market, which are believed to have been caused not so much by the effects of industrial recession but also by some running down of stock at users' works as the supply situation eased. Compared with the corresponding period of 1953 acid output in the first quarter was only about 4% lower, the most significant drop in sulphur consumption occurring in the rayon industry.

As anticipated, the increased rate of production has resulted in a substantial improvement in the stock position, which, at the end of March, stood at 3,238,838 tons. Compared with above ground stocks at end 1953 this tonnage is 216,352 tons greater and is the highest since autumn 1948.

Fig. IV

MONTHLY PRODUCTION FIGURES 1953 to 1954



Recovered sulphur

Production of sulphur recovered from natural and oil refinery gases during the first quarter 1954 amounted to 85,000 tons. This tonnage is 2,000 tons (2½%) greater than during the preceding quarter, and 2,500 tons (3%) greater than during the corresponding period of 1953. The increase is attributable to March output of 30,000 tons, which was thus again at the high level attained only during June and July of last year. Apparent sales of 60,782 tons, in line with seasonal trends, were about 35,000 tons (36%) below the level of the preceding quarter, but over 10,000 tons (21%) higher than during the corresponding period of 1953. In consequence, stocks increased by over 24,000 tons to 131,562 tons at end March.

The salient points in the developments in the U.S. industry during the first quarter 1954 are thought to be as follows:-

(a) Total production of native and recovered sulphur at 1,463,300 tons was the highest on record. This corresponds to an annual rate of 5.85 million tons, or 6½% greater than the 1953 rate of production.

(b) Apparent sales of native and recovered sulphur were low at an annual rate of 4.87 million tons.

(c) Stocks of native sulphur rose to nearly 3¼ million tons, the highest level since autumn 1948.

Since the end of the first quarter some fluctuations in production have been reported, and a substantial increase in sales to domestic consumers has taken place, notably during April. At the same time, the supply position still continues to be described as easy.

UNITED KINGDOM SULPHUR

During the first quarter of 1954 consumption of sulphur in all forms amounted to about 215,000 tons, or about 3½% more than the tonnage consumed during the preceding quarter which had been the highest on record. Consumption of brimstone was fractionally below that of the preceding quarter which was the highest since the first quarter of 1952, and 3¼% higher than during the first quarter 1953. "Regular" sulphur consumption was the highest since 1950, whereas "acid" sulphur consumption receded slightly below the level of the fourth quarter 1953.

It is estimated that of the above total consumption 31½% was met from indigenous sources (sulphur in spent oxide, anhydrite, zinc smelter gases and recovered from oil refinery gases), 27½% in the form of imported pyrites and 41½% in the form of imported brimstone. Actual imports amounted to 92,814 tons brimstone (valued at £13.4s. per ton), 151,443 tons pyrites (valued at £7.1s. per ton).

Consumption of the various raw materials was as follows:-

	1st Qtr 1954	4th Qtr 1953	Change+	1st Qtr 1953	Change+
Sulphur					
acid	64500	65900	-2%	67300	-4%
regular	28800	27500	+4¾%	23100	+25%
Total	93300	93400	-	90400	+3¼%

	1st Qtr 1954	4th Qtr 1953	Change+	1st Qtr 1953	Change+
Pyrites	130300	116500	+12%	69600	+87½%
Spent Oxide	76800	76200	+¾%	71900	+6¾%
Zinc con.	49100	47300	+3¾%	41000	+20%
Anhydrite	44700	43800	+2%	50000	-10%

+ Percentage figures shown indicate change between earlier periods and first quarter 1954.

Monthly consumption figures of raw materials were as follows:-

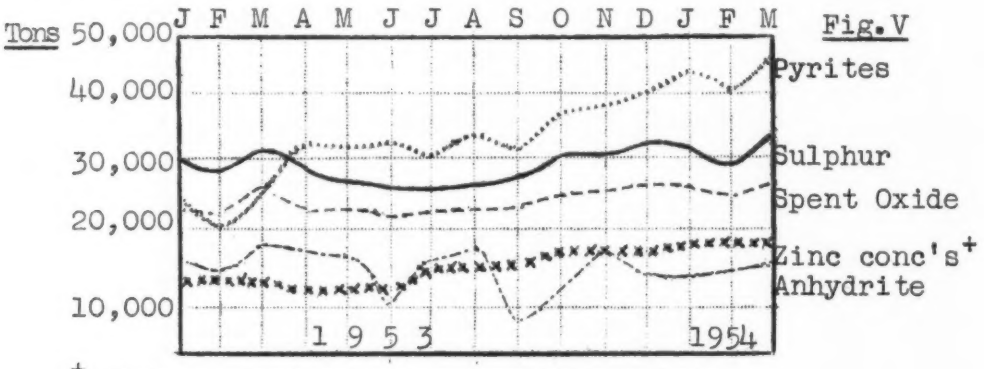


Fig.V

+ Note: graph based on quarterly data.

Sulphuric acid*

Production during first quarter amounted to 526,900 tons (100% H_2SO_4), the highest on record. Output representing an annual rate of over 2.1 million tons was 3% higher than during the preceding quarter, and 17% higher than during the corresponding period of 1953. Acid production resulted from the use of sulphur bearing raw materials in the following proportions:-

* The following particulars exclude all government plants and output, and capacity figures are therefore not strictly comparable with details of earlier periods.

	1st Qtr 1954	1953
Sulphur	34¾%	38¼%
Sulphur in pyrites	32¼%	27%
" " spent oxide	19¾%	20¾%
" " zinc smelter gases	8¼%	8¼%
" " anhydrite	5%	5¾%

During the first quarter 1954 overall utilization of acid capacity was 90.6%. Contact acid production of 351,600 tons amounted to exactly two-thirds of total acid production.

Completion of further pyrites roasting plants is estimated to have raised pyrites roasting capacity by end March, 1954, to about 620,000 tons per annum. Employment of sulphur burning capacity during the first quarter is believed to have amounted to about 75%.

Consumption of sulphuric acid amounted to 534,300 tons, the highest on record, an increase of 4% over the preceding quarter and 12½% higher than the annual rate in 1953. Compared with the corresponding period of 1953 the principal changes by consuming industries are as follows:-

	Tons	Increase
Titanium oxide	18,900	+59%
Dyestuffs	7,500	+52%
Rayon and transparent paper	6,400	+11%
Iron pickling	3,200	+13%

Notable increases in acid consumption, though quantitatively less important, were recorded for - Lithopone (+95%), Plastics (+65%), Bromine (+62%), and Soap and detergents (+30%). The only major decrease occurred in the oil refining industry where consumption decreased by 2,100 tons (-27%).

Stocks

During the first quarter 1954 sulphur stocks increased, for the first time since November, 1952, by

15,500 tons to 82,300 tons, which, at the current rate of consumption, would meet demand for just over 2½ months. At the end of January, 1954, pyrites stocks in the hands of the Government are estimated to have amounted to about 400,000 tons, and those held by consumers about 140,000 tons, since then only details of the latter are available for publication, and by end March they had increased to 145,900 tons, or sufficient for just over three months at the current rate of consumption.

Spent oxide stocks declined further to 163,500 tons, a decrease of 8% during the quarter. The end 1953 stock figure was 178,000 tons, and not 278,000 tons as erroneously printed.

The most significant features of sulphur development during the first quarter are:-

(a) The continued increase in sulphuric acid production and consumption to an annual rate in excess of 2.1 million tons.

(b) The continued high sulphur consumption for sulphuric acid making at an annual rate of nearly 260,000 tons, and regular sulphur consumption at an annual rate of 115,000 tons, the highest since the peak rates of 1950.

(c) The production of one-third of U.K. acid from imported pyrites.

On completion during the summer months of the last new pyrites acid plants installed under the conversion programme, it is intended that nearly 40% of U.K. sulphuric acid is to be produced from this raw material. At present, mainly on account of the easier world supplies and the high rate of U.K. acid consumption, acid sulphur users appear to experience little difficulty in obtaining more liberal supplies. When, however, the first additional anhydrite capacity will come into operation in the early autumn, it is apparent, failing an exceptional further rise of any acid requirements (considered unlikely), that by the end of 1954 acid sulphur usage will be restricted to a level nearer 200,000 t.p.a. The substantial reduction

of cheap acid availability is then likely to be reflected by a higher level of acid prices.

THE MASOBELLO PROCESS

This process was developed specifically for the treatment of Italian and Sicilian sulphur ore, but it is, of course, applicable to any sedimentary and volcanic ore. It is based on the complete distillation of the sulphur content of the ore followed by condensation, the refined sulphur accrueing in melted form. Distillation is effected in a group of vertical retorts which are enclosed in steam jackets.

The plant embodies a catalytic convertor similar to that of the Claus process in order to extract any combined sulphur from gas generated during the distillation process. The necessary sulphur dioxide arises in the retorts by controlled addition of air. Any free sulphur (vapour) that may have been carried along by the gas from the condenser is recovered by gas scrubbers. In cases when fine ore is present in the retort charge, dust precipitators eliminate impurities that might otherwise reduce the proportion of sulphur in the final product.

The plant is of all metal construction with the retorts made of stainless steel or cast iron, depending on the type of ore. The type of gangue material also determines the required distillation period, which varies from three-eight hours, the amount and composition of gas generated during distillation (H_2S, COS, CO_2, H_2O), and the amount of free sulphur combining with gangue.

Operation

Plant operation is fully automatic. Ore not larger than $1\frac{1}{4}$" is fed continuously by gravity from a bin on tope of the retorts, the rate of feed being controlled by an oscillating gate. Steam is generated by application of external heat (fuel oil burners), and is circulated round the retorts by a fan. The system is closed to minimise water loss. Molten sulphur from the condenser, catalytical

convertor and scrubber is collected in a tank from which it may be either pumped and stored in large vats, or cooled and cast mechanically in 100 lb. blocks or 1 lb. pieces.

Recovery

Depending on the type of ore, recovery of sulphur ranges from 86%-98%. Typical Italian ores showed the following results:-

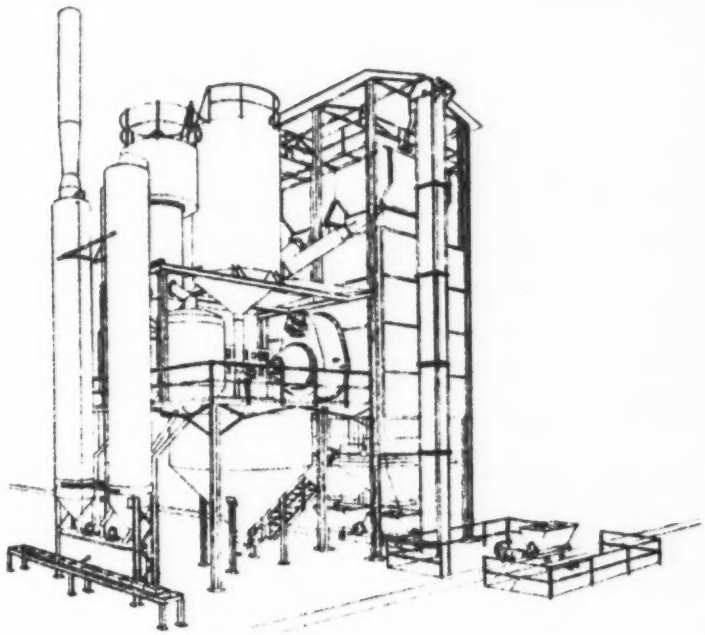
Ore	Recovery			Loss	
	Direct	From gas	Total	Gas	Tailings
Dusty ore 19%S 31%$CaCO_3$ 19½%$MgCO_3$ 21¾%Clay 3¾%Gypsum	73.5%	15.6%	89.1%	3.9%	7%
Volcanic ore 24.8%S Tuff with 9% moisture, 9% combined water	81.5%	14.8%	96.3%	3.7%	-
Limestone gangue 29.1%S	90.1%	6.4%	96.5%	1.5%	2%
Compact limestone gangue with bitumen 23.35%S	85%	7.6%	92.6%	1.9%	5.5%

The resultant sulphur is 99.7%-99.9% pure.

Ore capacity - consumption

The plant is constructed on the unit principle. A single unit has a capacity of 60-140 metric tons per day, depending on the type of ore. Up to 12 units can be combined giving proportionate output figures.

The plant is designed for fuel oil consumption which, according to the type of ore, varies between four-eight U.S. gallons per metric ton ore. Other fuels with corresponding calorific values may be used. Consumption of

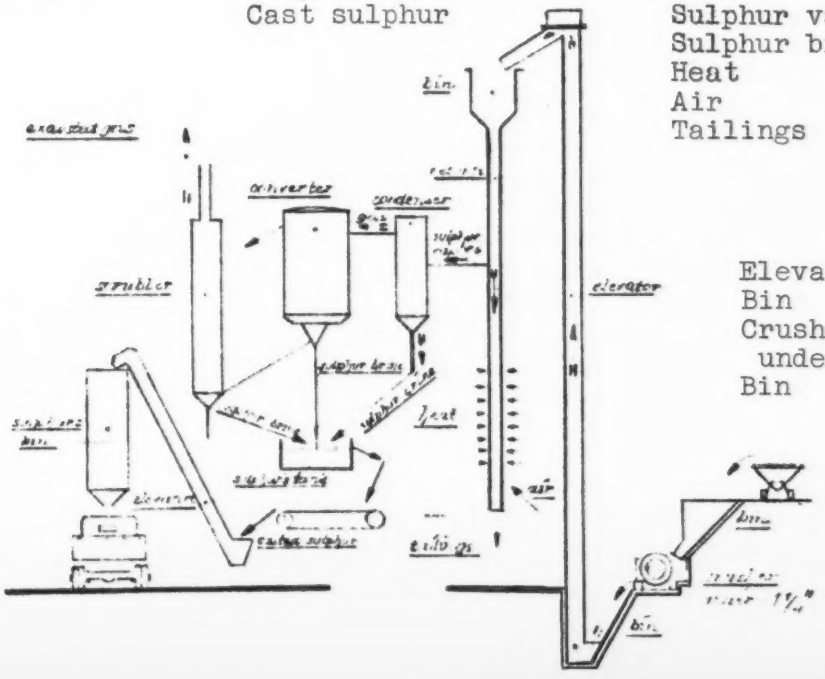


To facilitate reading the flowsheet below, the headings are as follows:

Exhausted gas
Scrubber
Sulphur bin
Elevator

Convertor
Sulphur brine
Sulphur brine
Sulphur tank
Cast sulphur

Bin
Retorts
Condenser
Gas
Sulphur vapour
Sulphur brine
Heat
Air
Tailings



Elevator
Bin
Crusher
under 1¼"
Bin

electric power is 10 KwH per ton of ore.

The life of retorts is said to be two years. In view of inconsistent results at pilot plant stage with retorts made of a wide range of alloy steels and cast iron with varying carbon content, a series of different retorts were incorporated in the first commercial plant (see below) in order to resolve this question under practical working conditions.

Labour requirements for a one unit plant are stated to be one supervisor and six operatives: for multi-unit plants labour requirements progressively decrease, e.g. 12 unit plant requires three supervisors and twenty-one operatives.

Makers and costs*

The plant is built by Italiana Gasogeni e Forni S.A. of Milan, subsidiaries of Impianti Speciali per L'Industria. The cost of a single unit plant, excluding ancillary equipment such as ore crushers, elevators, conveyors, fuel oil storage, sulphur casting plant, is about $165,000 (£60,000) ex works. For multiple units the cost proportionately decreases and a 12 unit plant shows about 20% reduction on unit cost.

Based on the assumption that, type of ore permits 100 tons per day throughput, fuel consumption is 6 U.S. gallons per ton ore at U.S.¢.9 per gallon, sulphur recovery is 92%, retort replacement period is two years (the incidence on cost per retort is shown in brackets below), amortization over ten years with 4% interest on $220,000 capital costs, repairs allowance of 3% p.a. on capital cost, mining and operational costs $2.35 per ton of ore, daily labour rates of Supervisor $20 and of Operatives $15, electricity ¢.20 per KwH, operating costs* for varying grades of sulphur content in ore are calculated as follows:-

* These data may serve as an indication only.

20%	Sulphur	in	ore	$30.46	($2.18)
30%	"	"	"	$20.30	($1.45)
40%	"	"	"	$15.23	($1.09)
50%	"	"	"	$12.18	($0.87)
60%	"	"	"	$10.15	($0.73)

These figures refer to single unit operations. For multiple units costs progressively decrease up to 40% in the case of a 12 unit plant.

Application

At present one plant, with a daily capacity of 120 tons ore is working under normal operating conditions. It was constructed by the makers in collaboration with Messrs Montecatini at the latter's Perticara mine in Northern Italy. Operations were started in March, 1954, but to date no specific operating data are available. A similar plant is being installed by the makers for the Compagnia Generale Zolfi at the Saponaro mine in Sicily. It is expected to be completed later this year. Work is in progress on the construction of a plant for the Musa Mining Company of Hokkaido, Japan, which is to be installed in 1955. The plant, which is to have an annual output of 18,000 tons refined sulphur per annum, is being prefabricated in Italy.

THE ZAHN PROCESS

This process, which has been developed by Zahn & Company of Hameln, Western Germany, is based on the use of carbon disulphide as solvent. Plant operation, as shown on the flow sheet is fully automatic.

Sulphur ore, after being reduced to suitable grain size in a grinding mill (1), is raised by a bucket elevator (2) to a bunker (3), from which it is mechanically fed into cages that carry it into the sulphur extraction plant (6). The cages containing the residue (gangue) are withdrawn from the extraction plant by means of a crane (17), lifted onto a transporter (18) which carries them to a discharging device (19) where the residue drops

into a bunker (20), whence a conveyor belt (21) removes the material to a heap. The empty cages return to the storage bunker (3) to be refilled with sulphur ore. Carbon disulphide is pumped (5) from the storage tank (4) to the extraction plant (6). The resultant sulphur solution is treated in a condenser (7) and then collected in an intermediate tank (8) and pumped (10) through a mud filter (11) to distillers (12). After passing through further condensers (14 and 15), sulphur is released through discharging locks and flows to collecting pits (13) to solidify.

All apparatus and piping are provided with gas protection and connected with the protection gas tank (16) by a pipe system.

Consumption figures of materials and services per ton of pure sulphur (99.8%) are stated by the makers to be as follows:-

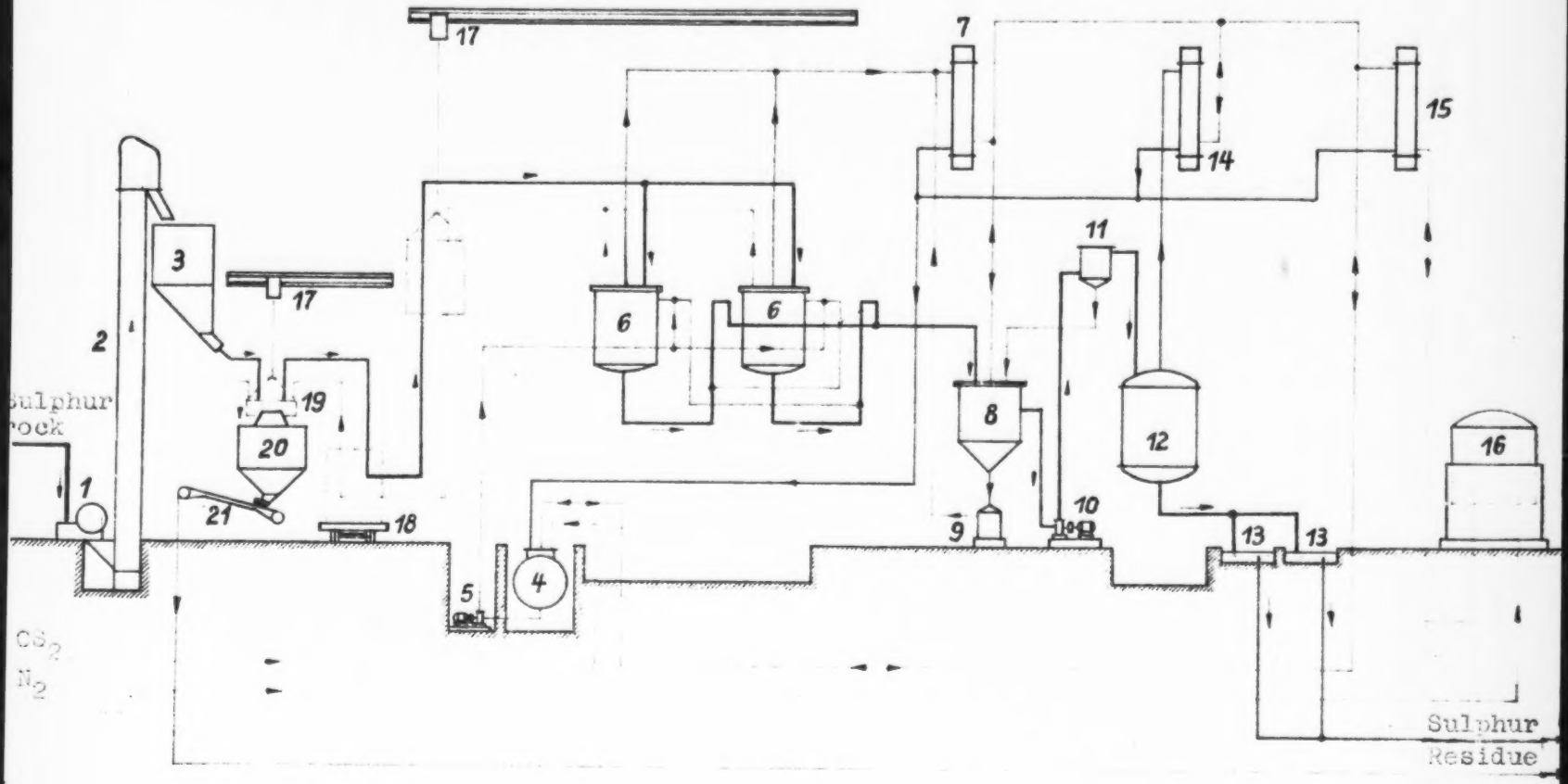
Carbon disulphide - 20-25 kg.
Steam - 1,200 kg.
Cooling water - 25 cubic metres.
Power - 32 kW.
Labour - 3 operatives per shift.

Sulphur recovery is stated to be minimum 95% of sulphur contained in ore, and the process is stated to be highly economic with operating costs much below those of autoclave operations.

Application

In April Sociedad Azufrera Polan started operations at their newly installed Zahn sulphur refining plant near San Pedro de Acacama. This plant is the first modern refinery to be erected in Chile, and, apart from an experimental plant that operated in the Argentine some two year ago, is the first plant ever to employ on a commercial scale the carbon disulphide process for the refining of sulphur ores of volcanic origin.

The refining plant is situated at an altitude of about 7,000 feet which is an unavoidable disadvantage since the company's mine is situated some 15 miles away,


17
7
15
14
3
17
11
2
6
6
Sulphur
rock
19
8
12
16
20
1
21
18
9
10
13
13
5
4
CS_2
N_2
Sulphur
Residue

high up in the Andes at a level of about 16,000 feet.

The new plant produces at a daily rate of 30 tons, the resultant sulphur having a purity of 99.7%. Ore used in the plant is the normal good quality caliche, containing 50%-55% sulphur, of which 96% recovery is being achieved.

Owing to excessive transportation costs from mine to plant and plant to shipping port, and the unfavourable level of official exchange rates, f.o.b. costs exceed those of U.S. Frasch sulphur. Actual production costs, however, are stated to be substantially below those of the autoclave plants in use by the bulk of Chilean sulphur producers.

THE EXIT GAS PLANT AT THE AVONMOUTH WORKS OF THE IMPERIAL SMELTING CORPORATION LTD. *

Towards the end of 1949 it was decided to modernise and raise the capacity of the existing Avonmouth sulphuric acid plant which is now 400 tons per day (100% H_2SO_4). In this scheme it was known that in raising the output of the present acid plant appreciably the efficiency of oxidation in the convertors would drop. These convertors operate on sulphur dioxide gases from sinter machines and pyrites burners. The residual or waste gases of the acid plant, i.e. the exit gases after absorption of the sulphur trioxide in concentrated sulphuric acid, are in normal practice passed to the atmosphere. In order to maintain and improve the overall sulphur recovery of the plant it was necessary to design and construct an Exit Gas Plant to scrub the unconverted sulphur dioxide from the waste gases and return it to the acid plant for the production of sulphuric acid.

The Exit Gas Plant was designed to handle 32,500 cu. ft. per minute of waste gases, and to produce one ton per hour of Grade 1 ammonium sulphate crystals. In line with modern developments in mechanization and automatic control, a plant of the most advanced type was designed, but in many instances equipment was constructed of materials

* We are indebted to the Imperial Smelting Corporation for the following article.

which were readily available and not in such short supply as would delay completion of the plant. The foundations were laid in December, 1951, and the plant commenced operations in April, 1953, after preliminary tests had been carried out during February and March.

Basically, the plant can be divided into three distinct sections. Firstly, the sulphur dioxide in the waste gases is absorbed in an ammonium sulphite-bisulphite solution; this solution is then treated with sulphuric acid yielding sulphur dioxide gas and a solution of ammonium sulphate. Finally, the ammonium sulphate is crystallised and the crystals dried ready for despatch.

For the first stage of the process, the waste gases pass through a lead tower packed with earthenware rings, over which the ammonium sulphite-bisulphite solution circulates. A large proportion of the sulphur dioxide in the gases is absorbed before the exit gases pass out to the atmosphere. In order to maintain the final exit at the required level, the acidity or pH of the circulating liquor is controlled automatically by the addition of 25% ammoniacal liquor. By these means satisfactory operation is obtained and ammonia loss to atmosphere is kept to a minimum. The specific gravity of the liquor is also closely controlled by the automatic addition of water.

From the pumping lines to the top of the scrubbing tower there is a continuous bleed of bisulphite liquor to the "decomposing section". To this liquor is added 96% sulphuric acid, which has already been used for drying the sulphur dioxide which is produced by the reaction and which gas is then distributed to the strong drying towers of the sulphuric acid plant. The free sulphuric acid in the ammonium sulphate solution produced is neutralised with ammoniacal liquor automatically.

The next stage of the process is the evaporation of water from the ammonium sulphate solution and the production of ammonium sulphate crystals. This is done in a vacuum crystalliser which was designed to achieve the efficient use of steam and approximately 0.6 lb. of steam is required for each 1 lb. of water evaporated.

The crystallisers are two cylindrical rubber-lined mild steel vessels in series, the first crystalliser having six compartments and the second five compartments. Liquor overflows from compartment to compartment through stand-pipes which maintain each compartment approximately half full. Prior to the first crystalliser is another rubber-lined vessel known as the pre-evaporator. The pre-evaporator and the first four compartments of the crystallisers are each connected to its own heat exchanger, and these consist of stainless steel tubes in rubber-lined shells.

The ammonium sulphate liquor is pumped through the heat exchangers in turn and is heated by the vapour from the early crystalliser compartments. From the fifth heat exchanger the liquor passes to a sixth which is steam heated. In this way, the liquor is heated to the required temperature as economically as possible and an almost ideal heat balance is obtained. The vapour, after giving up its heat to the liquor, condenses and runs out of the heat exchangers through barometric legs. This condensate contains some ammonium sulphate and is pumped from a small tank for use as make-up water in the scrubber tower. Vapour from the remaining seven crystalliser compartments passes through two water spray condensers. In order to provide the required vacuum a series of steam ejectors are used, giving a vacuum of 25-35 mm. mercury.

The hot sulphate liquor passes from the final heat exchanger to the pre-evaporator where water is flash evaporated and its temperature falls. The liquor then passes from compartment to compartment cooling by evaporation a few degrees at a time. In the fourth compartment the crystal nuclei start to form, and the crystals then grow to the required size in the remaining compartments. A small amount of air is bled into the bottom of the compartments to maintain agitation and prevent the crystals settling out.

From the end compartment of the second crystalliser, the crystal slurry overflows by gravity through a barometric leg to the slurry tank. The slurry is then pumped to a lead-lined settling cone. Here the crystals settle and the clear mother liquor overflows to the liquor tank to be recirculated with fresh liquor. The crystals are

fed from the bottom of the cone to an agitated holding tank from which the suspension is fed to a centrifuge.

From the centrifuge the crystals pass through a Simons shaker dryer, being dried by hot air. The dry crystals are then screened before passing via an elevator and conveyor belt to bulk storage.

During the first year of operation many problems of operation have been encountered, but despite these difficulties ammonia and sulphur dioxide recoveries are at the expected high levels and the output of ammonium sulphate crystals is of the required quality.

CYPRUS

Pyrites production and exports 1953

From the recently published Annual Report for 1953 of the Inspector of Mines it appears that the sulphur value of iron and copper pyrites exports from the island amounted to about £2½ million. Their importance to the country's economy, apart from such invisible benefits as employment, taxation, etc., is manifested by the fact that they represent one-seventh of the total value of all exports, or about one-third of the total value of mineral exports. Quantitatively pyrites are the largest export commodity.

The following table shows the relevant mineral exports from Cyprus in 1952 and 1953, and an estimate of their sulphur content.

	1953			1952		
	Tons	Value £000	S cont. 000s tons	Tons	Value £000	S cont. 000s tons
Iron Pyrites	565183	2703	274	633270	2654	306
Copper Pyrites	129915	1194	61	146672	1364	70
Copper conc's	81085	2808	35	115500	4849	49
Total Sulphur			370			425

The following are details of the activities during 1953 of the three individual producers.

Cyprus Mines Corporation. The main emphasis of this, U.S. owned, company's activities is on its copper operation, and these predetermine to a large extent the arisings of pyrites concentrates. In 1953 ore output, originating wholly from the company's Mavrovouni mine, and containing an average of about 3¼% copper, 48.1% sulphur, amounted to 681,652 tons, about 63,000 tons less than in 1952. Of this tonnage 95,871 tons cupreous pyrites were crushed preparatory to direct export shipments and the concentrating plant at Xeros treated 567,608 tons of ore, thus employing 79% of its capacity.

Details of the resultant concentrate products and particulars of exports are shown in the Statistical Appendix. The bulk of the company's cupreous and iron pyrites exports which totalled 513,851 tons was, as in previous years, directed to acid makers in the U.K. and Western Europe. The copper concentrates were shipped to the company's traditional customers in U.S.A. and Western Germany, where apart from extraction of copper the sulphur content of about 42% is also utilised in by-product acid manufacture.

The company's Skouriotissa and Apliki mines which contain substantial tonnages of cupreous pyrites (48%S and 1.5%Cu) remain closed on a maintenance basis. Further improvements to the ore treatment plant, which had been substantially modified by an addition to an acid leeching plant in 1952, led to improved recovery in concentrates, notably of copper. The electro-magnetic geophysical survey, started in 1952, was completed in 1953 and provided up-to-date coverage of most of the company's leased areas, a large proportion of the prospecting permits and some areas held by other interests.

Hellenic Mining Company. This company produces iron pyrites only which are mined in three lease areas. With the exception of a ngligible tonnage all of the company's output has to be subjected to ore treatment and ore dressing is effected at the company's washing plant at Vassiliko. Production from the oldest mine Kalavossos still provided in 1953 about 55% of the company's total

output of high grade export ore, which in 1953 totalled about 152,000 tons. In view of the diminishing ore reserves, however, output continues to decrease and the life of Kalavossos is limited to perhaps no more than a further three years.

In the other two lease areas (Kambia-Sha and Agrokipia-Mitsero), mining operations on four deposits have started within the last three years. Exploration and development work continues in these areas, and also near Asproyia, where pyrites with low copper and silver values have been discovered. Operations in these four areas are partly open-cast and partly underground, and production during 1953, totalling 115,341 tons, varied from 10,000 tons at Kokkinonero (Kambia lease area) where stoping started in 1953, to about 50,000 tons mined at the company's Kokkinopezoulo deposit (Mitsero area). Ore from the Kambia-Sha deposits yielded on treatment high grade ore in proportion to low grade ore at the ratio of about 3-1 and better, while less favourable results were obtained with ore from Agrokipia 5-2, and Mitsero 6-5. The average grade of the company's 1953 exports of 149,067 tons was 45.65% sulphur and 0.074% copper.

Cyprus Sulphur & Copper Company. This company, a subsidiary of the U.K. domiciled Esperanza Sulphur & Copper Company, works two deposits of pyrites ore containing important non-ferrous and precious metal values. The deposit at Limni, believed to have been worked for copper in Roman times, has estimated ore reserves of about $5\frac{3}{4}$ million tons, of which one-fifth is pyrites gold ore containing 3 dwt. Au, 23 dwt. Ag, 0.83% Cu, and 20.4% S. The balance is copper ore containing 1.39% Cu, 18.8% S, as well as a small ore body of yellow ore (4.99% dwt. Au, 46.49 dwt. Ag) and stopes of high grade iron pyrites.

An ore treatment plant is on the point of completion and the degree of possible recovery of the various constituents of the Limni ore will determine future exploitation. At the Kinousa deposit, which was discovered in 1950, proved and probable reserves determined so far are said to be about 200,000 tons ore containing 3-3.4% Cu, 43-44% S, 4-5% Zn. There are also indications of about 150,000 tons of similar pyrites ore with lower metal values and about 400,000 tons low grade ore (24%S) some

distance south of the main ore body.

During 1953 production at Kinousa amounted to 26,689 tons high grade, and 17,793 tons low grade ore, the latter being stockpiled for further treatment; during the same period 2,274 tons high grade pyrites were produced from Limni. The average grade of the company's exported copper pyrites which totalled 32,180 tons was 3.016% Cu, 44.62% S.

Mine production of Cypriot pyrites in 1953 was about 6½% below that of 1952 with exports showing a drop of 11%. The main reason appears to be the reduced scale of copper operations by Cyprus Mine Corporation, which, in 1952, had been exceptionally high.

In view of the high quality of Cypriot pyrites, notably their freedom from arsenic, consumers' demand has been maintained at a time when other pyrites exporters, such as Spain, suffered a heavy reduction of their export tonnage. In the light of developments the current level of production of exports is not expected to change appreciably. With exports of sulphur in pyrites and copper concentrates of nearly 400,000 t.p.a. Cyprus is likely to remain the largest sulphur exporter in the British Commonwealth for several years to come.

SPAIN

Pyrites production, consumption and exports 1953*

Although quantitatively Spain ranks second to Japan, the largest pyrites producer in the world, its international importance notably to the acid industry of Western Europe, as a source of sulphur supply in the form of pyrites, is supreme. This interdependence with the acid markets of a large number of countries is reflected in the fluctuations of Spanish pyrites output, and, as was the case in 1953, these may be of considerable magnitude.

* For statistical details see Appendix

Total production of iron and copper pyrites amounted to 2,084,842 tons, a decrease of nearly half a million m. tons compared with 1952, wholly as a result of reduced exports. Of the five principal importers of Spanish pyrites the requirements of four, namely, U.K., France, Belgium and Holland, were severely reduced, and only those to Western Germany exceeded 1952 levels. As approximately three-quarters of Spanish exports of 1,191,573 m. tons pyrites (containing about 580,000 tons sulphur) are effected by the two largest producers Rio Tinto Company Ltd, and Tharsis Sulphur & Copper Company Ltd, both U.K. domiciled concerns, it is not surprising that over two-thirds of the reduction in exports and also of production have to be borne by them.

Spanish domestic consumption continued to increase in 1953, and amounted to 762,032 metric tons, about 8,000 tons more than in 1952. Of this tonnage actual consumption for acid making was about 565,000 metric tons. The balance includes pyrites consumed by Rio Tinto for the production of elemental sulphur and blister copper by the Orkla process, pyrites laid down for heap leaching of copper and consumed for other production.

The following developments in 1953 might be mentioned:

Rio Tinto Company. The company started operation of a heavy media flotation concentrating plant which uses old stocks of low grade washed ore, containing about 30% sulphur, to produce a pyrites concentrate of 48%-50% sulphur. The capacity of the plant is 200,000 t.p.a. and in 1953 it is believed to have operated at about one-third capacity.

Cueva de la Mora. The anticipated production of sulphur and flotation pyrites did not materialise. It is reported that production is not now expected to start in the foreseeable future.

Murcia. In 1953 Minerales de Cartagena S.A. (Minecasa) was the sole exporter of pyrites from this region, disposing in addition to its own production and that purchased from neighbouring mines, the export tonnage purchased from Empresa Celdran, the region's principal producer. In December, 1953, Minecasa terminated its

activities as pyrites producer, merchant and exporter. Export demand for Murcia pyrites has much decreased owing to their inferior quality and several mines have discontinued production, so that output in this region is expected to be much reduced.

Santander. Progress during 1953 at the new Hinojedo sulphur plant of Cia Real Asturiana is expected to result in elemental sulphur production from pyrites being started during the current year. A target of 10,000 tons sulphur per annum has been mooted, which, in view of the company's pyrites requirements for acid making, and their customary exports to Belgium, may necessitate an increase of pyrites output.

Seville. The Cuchichon mine at Aznalcollar is expected to come into production in 1954 with an output of cupreous and iron pyrites.

According to recent reports export demand for Spanish pyrites has much improved in the early months of this year.

CURRENT EVENTS

Australia

Sulphur Bounty

Further public hearings in connexion with the payment by the Tariff Board of a subsidy to acid manufacturers using indigenous raw materials in preference to imported sulphur were held in April and May of this year. Evidence presented by the many interested parties, mainly sulphuric acid manufacturers and pyrites producers, disclosed widely divergent views as regards the extent of the required subsidy. It is questionable whether, in view of the easement in world sulphur supplies, coupled with the unfavourable economics of the use of pyrites, their large-scale employment, which implies a considerable measure of Government backing and subsidy, is likely to be supported. The enquiry is still proceeding.

Sulphide Corporation Proprietary Ltd.

During 1953 total production of sulphuric acid at the company's Cockle Creek, N.S.W., works amounted to 52,560 tons (100% H_2SO_4). This tonnage was produced from the following raw materials:-

Sulphur	15,074 tons
Pyrites	6,603 "
Spent oxide	672 "
Smelter gases	-

In the annual report for 1953 of their U.K. parent company, the Consolidated Zinc Corporation, the Chairman referred to the partial easing of the sulphur supply position in Australia which enabled Sulphide Corporation to suspend temporarily manufacture of acid from pyrites.

British West Indies

Trinidad: Recovered sulphur

In the survey of sulphur recovery from oil refinery gases in Bulletin No.4, a reference was omitted in the statistical summary to the production of sulphur at the oil refinery of Trinidad Leaseholds Ltd. Current production amounts to 5,000 t.p.a. which details should be included on pp.35 and 36. It might be added that this refinery has been operating since mid-1948, and until November, 1953, it produced at the rate of 1,600 t.p.a. supplying about 90% of the refinery's own requirements for sulphuric acid manufacture. The new production leaves a substantial margin for export. (See also Bulletin No.4, p.54.)

United States of America

Off-shore sulphur discovery

At the end of June this year the Humble Oil & Refining Company confirmed reports that it has struck an underground sulphur deposit about six miles off-shore from Grand Isle off the south-east coast of Louisiana. No indications have

yet been given by the company of the size of this discovery, although sources in the industry believe it to be a major find.

So far, two wells some 2,000 feet apart have been drilled to a depth of 2,500 feet, and drilling is to continue at the rate of one well per month throughout a two-year proving programme.

The Humble Oil & Refining Company are stated to hold this under-water lease from the Federal Government, but it is understood that, in view of the complexities of Federal and Louisiana State legislation affecting off-shore leases, the exact terms and conditions of exploitation are as yet undefined. It is believed that capital costs of a mid-sea installation may be two to three times greater than the equivalent land or marsh installation. Operating costs are also liable to be heavier, and it is considered doubtful whether, at present sulphur prices, this dome could be worked profitably. Nevertheless, the confirmation of the existence of an off-shore dome sulphur deposit is an important addition to known world sulphur supply prospects.

Italy

Exploration in Northern Italy

According to an unconfirmed report an Italian sulphur combine is at present exploring in Northern Italy from the Adriatic to Umbria. This work is inspired by the hope of finding, associated with the extensive natural gas deposits of the Po plain, sulphur formations similar to those of Texas, Louisiana and Mexico, which would permit economic exploitation. The stagnation of the Sicilian sulphur industry is thought to be a contributary factor in promoting this sulphur search.

Norway

New sulphuric acid plant

According to a report in "Chemische Industrie", production started recently at a new sulphuric acid plant of

A/S Borregaard, the important Norwegian chemical enterprise. The plant has a capacity of 22,000 t.p.a., which is to be based on the use of pyrites. These are to originate from the mines of Folldal Verk A/S in which A/S Borregaard have a substantial interest.

Poland

New sulphur deposit

According to a recent official Polish Press report a major sulphur deposit has been discovered. It is stated that test borings have disclosed reserves larger than those in Sicily. Development work is said to be progressing and production is expected to start in 1955.

Cuba

Pyrites

It is reported that pyrites production and exports are to be expanded substantially during the current year. The principal producers of pyrites, as reported in Bulletin No.4, are Cia Minera Cortes S.A. of Havana. Production and exports are expected to reach 150,000 t.p.a. pyrites containing 48% sulphur and 1% copper. Amongst European pyrites consumers much interest is shown for this production particularly in Italy and Belgium.

Mexico

Texas International Sulphur Company

Since 1st April this year, the company's refining plant has produced satisfactorily at the rate of 30 tons per day sulphur. Virtually the entire output has been placed for local use in Lower California (Mexico), and Southern California (U.S.A.), at a remunerative price. (U.S. Gulf sulphur is delivered in this region at a price of about $40-$42 per ton.)

Mexican Gulf Sulphur Company

According to a recent report by the company's President, Mr Paul Nachtman, the refining plant at San Cristobal has been in continuous operation since 15th March, 1954. Production is slowly increasing as heating of the formation is extended, and the company hope to approach the designed capacity of their plant of 200,000 t.p.a. within the next three or four months. In the meantime, minor mechanical changes in the light of experience are being effected. At present production is believed to be at the rate of 350 tons per day. For the time being the entire output is being stockpiled and this, together with the next four or five months' production, is earmarked for Mexican consumption. It is understood that the company have, as yet, not made any export commitments, but envisage doing so in the early autumn when they hope to have completed their loading facilities at Puerto Mexico. These are intended to permit export shipments at the rate of 10,000-12,000 tons per month, and the President of the company stated that their first preference would be for those countries that contributed to Mexico's economy.

The photographs on the opposite page are reproduced by courtesy of the Mexican Gulf Sulphur Company.

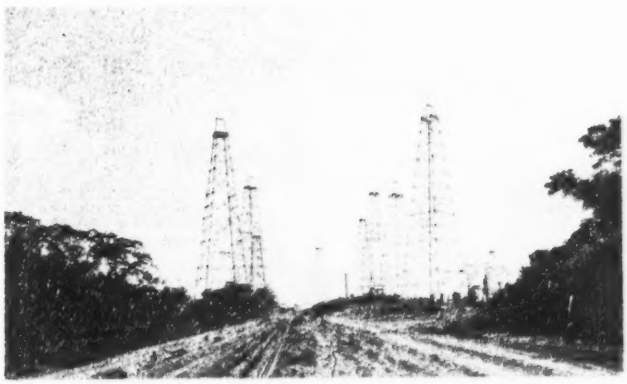
Japan

Sulphur production and consumption 1953 and 1954

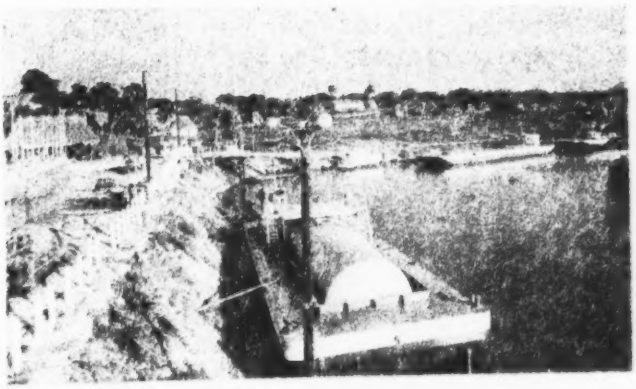
Production of sulphur during 1953 amounted to 189,549 tons, about 10,000 tons more than during 1952. The high level of production was the result of a substantial increase in domestic requirements which, during 1953, amounted to 172,389 tons, or 37,000 tons (27%) more than in 1952.

The following table shows mine production by individual producers, together with an estimate of their production during the current year:

Power plant showing chemical treating units (right centre) and oil day tanks. Three Babcock & Wilcox boilers (left centre). Plant is all steel and aluminium construction.



Production wells and steam, air and sulphur pipe-lines.



Liquid sulphur barges alongside San Cristobal Dock. Sulphur storage vat under construction (extreme left centre).

Production	1953	1954 est.
	metric tons	
Matsuo Mining Co. Ltd.	61393	63300
Hokkaido Sulphur Co. Ltd.	24395	26000
Teikoku Sulphur Co. Ltd.	14008	14500
Nihon Tokushu Kogyo Co. Ltd.	11995	12400
Nihon Ryutetsu Co. Ltd.	8350	8600
Shirane Sulphur Co. Ltd.	8629	8900
Naruko Sulphur Co. Ltd.	8366	9200
Zao Mining Co. Ltd. & others	52413	49660
Total	189549	192560

The increase in domestic consumption resulted mainly from greater requirements of the pulp and rayon industries, whose sulphur consumption compared with 1952 rose by 24% and 21½% respectively. Details for 1953 and an estimate for consumption in 1954 are as follows:-

Consumption	1953	1954 est.
	metric tons	
Carbon disulphide	80471	95000
Pulp	72218	76000
Agricultural chemicals	3700	3000
Others	16000	12000
Total	172389	186000

Exports during 1953 amounted to 13,000 tons, which were almost exclusively directed towards Australia. For the current year the anticipated export tonnage is only 6,000 tons, wholly due to the disparity between Japanese and world prices. In order to make Japanese sulphur competitive in the future, intensive research is being carried out into rationalization and modernization of the industry.

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STATISTICAL APPENDIX

WORLD

Native and Recovered Sulphur Production (000s tons)

	1951	1952	1953
U.S.A.	5462.2	5541.2	5492.4
Canada	-	2 e	18 e
Mexico	30.8	47.8	45 e
Colombia	2.3	2.6	4.0
British West Indies	1.6	1.6	3 e
Ecuador	-	2.4	3 e
Chile	29.7	49.9	33.3
Brazil	-	-	1 e
Argentina	7.6	7 e	10 e
Peru	~~1.0~~ 2.2	~~2.5~~ 5.1	3 e
Bolivia (Exports)	9.0	5.5	2.5
United Kingdom	4.7	14.8	25.7
France	10.5	15.3	10.9
Belgium	0.4	0.4	0.2
Holland	0.6	3.8	11.9
Western Germany	45.3	51.1	59.6
Spain	39.0	40.4	45 e
Portugal	13.9	15.5	16.6
Norway	96.9	103.1	101.7
Sweden	13.6	17.5	23.8
Italy (Fused)	209.8	232.7	224.2
Turkey	7.3	8.2	9.7
Egypt	8.6	6 e	8 e
Iraq	-	0.6	5 e
Iran	1.5	1.5	1 e
Formosa	2.7	5.0	2 e
Japan	140.2	176.6	189.5
New Zealand	-	0.5	-
TOTAL	6139.2	6355.5	6350.0

e = estimate

CYPRUS

Pyrites Exports 1953 (tons)

Cupreous pyrites

	Cyprus Mines Corp.	Cyprus Sulphur & Copper Co.	Total
Italy	58320	-	58320
W. Germany	39415	32180	71595
	97735	32180	129915

Iron pyrites

	Cyprus Mines Corp.	Hellenic Mining Co.	Total
United Kingdom	108079	25663	133742
France	161046	-	161046
W. Germany	-	82254	82254
Italy	-	10857	10857
Switzerland	-	4990	4990
Holland		25303	
Belgium	105135	-	130438
Egypt		-	
	374260	149067	523327

Grand Total 1953 (Including 41,856 tons low grade solea flotation pyrites shipped by C.M.C. to U.K. and W. Germany.) 695098

Grand Total 1952 779942

Cyprus Mines Corporation

Output of concentrates

	1953			1952		
	tons	%S	%Cu	tons	%S	%Cu
Pyrites	422970	49.89	0.4e	457921	50.3	0.4e
Copper	73181	42e	4.16	100003	42e	18.04

e = estimate

SPAIN[+]

Pyrites (metric tons)

	Production	Exports
Rio Tinto Co.	932556	494192
Tharsis Copper & Sulphur Co.	625176	418275
Minas de Herrerias	98471	70247
Soc. Francaise des Pyrites	84472	53158
San Telmo Iberica Minera	49796	39877
Empresa Celdran	99246	-
Minecasa	7602	83789
Real Cia Asturiana de Minas	48440	12061
Others	139083	19974
Total 1953	2084842	1191573
Total 1952	2574068	1682499

Exports

	1953	1952
United Kingdom	276199	422236
France	87518	230494
W. Germany	418637	398099
Belgium	137097	243227
Holland	134630	222211
Denmark	63247	67980
Others	74245	98252
Total	1191573	1682499

[+] We are indebted to Instituto Nacional de Industria for this information.

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